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(54) Title of Invention: IMMERSION TYPE PROJECTION EXPOSURE APPARATUS(57) Abstract

**Purpose:** To provide an immersion type exposure apparatus that is able to utilize conventional process technology.

**Constitution:** A projection exposure apparatus equipped with an illumination means that illuminates a reticle, a projection optical means that projects the pattern on the reticle illuminated thereby onto a wafer, and a positioning means that positions the wafer at the prescribed position; wherein the projection optical means is equipped with an optical element that is opposite the exposure surface of the wafer and has a flat surface or a protruding surface that protrudes toward the wafer side and a liquid tank for holding liquid that fills at least the space between the exposure surface of the wafer and the flat surface or the protruding surface of this optical element.

Scope of Patent ClaimsClaim 1

An immersion type projection exposure apparatus; characterized in that, in a projection exposure apparatus equipped with an illumination means that illuminates a reticle, a projection optical means that projects the pattern on the reticle illuminated thereby onto a wafer, and a positioning means that positions the wafer at the prescribed position, the projection optical means is equipped with an optical element that is opposite the exposure surface of the wafer and has a flat surface or a protruding surface that protrudes toward the wafer side and a liquid tank for holding liquid that fills at least the space between the exposure surface of the wafer and the flat surface or the protruding surface of this optical element.

Claim 2

An immersion type projection exposure apparatus described in Claim 1; characterized in that the positioning means is equipped with an alignment measurement means that detects the wafer position, a focus position detection means that detects the position of wafer exposure surface with respect to the focus position of the projection optical means, a wafer drive means that holds and drives the wafer in the X and Y directions parallel to the exposure surface thereof and also in the  $\theta$  direction around the axis that is perpendicular to these, the Z direction, and in a direction in which the wafer is tilted toward the desired direction, and a wafer conveyance means that carries the wafer onto and out from the holding position of the wafer drive means.

Claim 3

An immersion type projection exposure apparatus described in Claim 2 in which the optical element that opposes the wafer is plane parallel glass.

Claim 4

An immersion type projection exposure apparatus described in Claim 2; characterized in that the projection optical means has a lens barrel, the optical element that opposes the wafer is attached to the lower end of that lens barrel, and a seal member is provided between that optical element and the lens barrel.

Claim 5

An immersion type projection exposure apparatus described in Claim 2; characterized in that the optical element that opposes the wafer can be moved in the optical axis direction thereof and positioned at the desired position.

Claim 6

An immersion type projection exposure apparatus described in Claim 2; characterized in that coated onto at least one of the flat surface or the protruding surface that protrudes toward the wafer side of the optical element that opposes the wafer and the exposure surface of the wafer is a coating material that has an affinity to the liquid used to fill the space between both of these surfaces.

Claim 7

An immersion type projection exposure apparatus described in Claim 2; characterized in that the upper surface of the liquid tank is released.

Claim 8

An immersion type projection exposure apparatus described in Claim 2; characterized in that the liquid tank forms a closed space.

Claim 9

An immersion type projection exposure apparatus described in Claim 8; characterized in that the liquid tank has a window for wafer transport that can be opened and closed.

Claim 10

An immersion type projection exposure apparatus described in Claim 8 in which the liquid tank forms a vacuum chamber.

Claim 11

An immersion type projection exposure apparatus described in Claim 8 that has a pressure gauge for detecting the pressure inside the liquid tank.

Claim 12

An immersion type projection exposure apparatus described in Claim 8 that has at least one of a pressurization means or a pressure reduction means for the liquid supplied inside the liquid tank.

Claim 13

An immersion type projection exposure apparatus described in Claim 8; characterized in that it has a pressurization means for the liquid inside the liquid tank.

Claim 14

An immersion type projection exposure apparatus described in Claim 7 or 8; characterized in that the liquid tank is positionally secured with respect to the optical means.

Claim 15

An immersion type projection exposure apparatus described in Claim 7 or 8; characterized in that the wafer drive means has an XY stage for moving the wafer in the X and Y directions, which are parallel to the exposure surface thereof, and the drive means thereof, and the liquid tank is positionally secured to the XY stage.

Claim 16

An immersion type projection exposure apparatus described in Claim 14 or 15; characterized in that the wafer drive means has an XY stage for moving the wafer in the X and Y directions, which are parallel to the exposure surface thereof, and the drive means thereof, and the drive portion of the XY stage is positioned outside the liquid tank.

Claim 17

An immersion type projection exposure apparatus described in Claim 7 or 8; characterized in that the wafer drive means has an XY stage for moving the wafer in the X and Y directions and a fine movement stage that tilts the wafer in the desired direction, and the liquid tank is arranged on the XY stage.

Claim 18

An immersion type projection exposure apparatus described in Claim 17; characterized in that a fine movement stage is arranged inside the liquid tank, the liquid tank is formed by materials with high permeability, and the fine movement stage and the XY stage are magnetically linked via the liquid tank.

Claim 19

An immersion type projection exposure apparatus described in Claim 14 or 15; characterized in that the liquid tank is formed using a low heat expansion material.

Claim 20

An immersion type projection exposure apparatus described in Claim 14 or 15; characterized in that the positioning means has a means that detects the wafer position by means of a laser interferometer, and the liquid tank has a window for this laser interferometer.

Claim 21

An immersion type projection exposure apparatus described in Claim 14 or 15; characterized in that the positioning means has a means that detects the wafer position by means of a laser interferometer, and this laser interferometer is secured to the liquid tank.

Claim 22

An immersion type projection exposure apparatus described in Claim 14 or 15; characterized in that it is equipped with a liquid supply control means that supplies the liquid to the liquid tank and controls the amount and the level thereof.

Claim 23

An immersion type projection exposure apparatus described in Claim 22; characterized in that the liquid supply control means has a means that filters the supplied liquid.

Claim 24

An immersion type projection exposure apparatus described in Claim 14 or 15 that is equipped with a means that excites the liquid that has filled the liquid tank.

Claim 25

An immersion type projection exposure apparatus described in Claim 14 or 15 that has a means that excites the wafer.

Claim 26

An immersion type projection exposure apparatus described in Claim 14 or 15 that has a means that excites the optical element that opposes the wafer.

Claim 27

An immersion type projection exposure apparatus described in Claim 25 or 26 in which the excitation means is an ultrasonic wave excitation apparatus.

Claim 28

An immersion type projection exposure apparatus described in Claim 14 or 15 that is equipped with a temperature control means that measures and controls the temperature of the liquid supplied inside the tank.

Claim 29

An immersion type projection exposure apparatus described in Claim 14 or 15 that is equipped with a refractive index measurement means that measures the refractive index of the liquid supplied inside the tank.

Claim 30

An immersion type projection exposure apparatus described in Claim 14 or 15 that is equipped with a stabilizer that inhibits fluctuation of the liquid supplied inside the tank.

Claim 31

An immersion type projection exposure apparatus described in Claim 14 or 15 in which the outer wall of the liquid tank is covered by a heat insulating member.

Claim 32

An immersion type projection exposure apparatus described in Claim 14 or 15; characterized in that the wafer drive means is equipped with a wafer chuck that uses suction to hold the wafer, and this wafer chuck has a conduit for performing suction holding by vacuum suction of the wafer and a shutter that prevents the liquid from flowing into this conduit.

Claim 33

An immersion type projection exposure apparatus described in Claim 14 or 15; characterized in that the wafer drive means is equipped with a wafer conveyance means that carries the wafer in and out of the exposure position inside the liquid tank, and this wafer conveyance means is such that at least a portion is arranged inside the liquid tank.

Claim 34

An immersion type projection exposure apparatus described in Claim 33 in which the conveyance means has a means that transports the wafer vertically or at an angle to the liquid held inside the liquid tank and levels the wafer in the liquid.

Claim 35

An immersion type projection exposure apparatus described in Claim 33 in which the conveyance means is a means that subjects at least one side of the wafer to air flow when the wafer is transported from inside the liquid held in the liquid tank.

Claim 36

An immersion type projection exposure apparatus described in Claim 14 or 15; characterized in that it has a pump that supplies liquid to and drains it from the inside of the liquid tank. There is. [Translator's note: Apparent typo]

Claim 37

An immersion type projection exposure apparatus described in Claim 7 or 8; characterized in that the wafer drive means has an XY stage for moving in the X and Y directions and a fine movement stage that, through this, is moved in the X and Y directions and tilts the wafer in the desired direction, and the liquid tank is secured on the fine movement stage.

Claim 38

An immersion type projection exposure apparatus described in Claim 37; characterized in that the bottom surface of the liquid tank forms a wafer chuck that holds the wafer.

Claim 39

An immersion type projection exposure apparatus described in Claim 37; characterized in that at least two side surfaces of the liquid tank are formed by flat surfaces that are at right angles, and these flat surfaces form a laser light reflection surface.

Claim 40

An immersion type projection exposure apparatus described in Claim 18; characterized in that the bottom surface member of the liquid tank and the bottom surface of the fine movement stage form a flat surface guide of a hydraulic bearing.

Detailed Explanation of the Invention

[0001]

Industrial Field of Application

The present invention relates to an immersion type projection exposure apparatus for exposing a detailed circuit pattern on a wafer in the semiconductor manufacturing process.

[0002]

Prior Art

Miniaturization of semiconductor elements has progressed, and, conventionally, for exposure light sources, there has been a shift from the g-rays of high pressure mercury lamps to i-rays with shorter wavelengths. Therefore, since higher resolving power is necessary, the NA (numerical aperture) of the projection lens must be made larger, and for that reason, the trend is toward making the depth of focus increasingly shallow. As is generally well known, these relationships can be expressed by the following equations.

$$(\text{Resolving power}) = k_1 (\lambda / \text{NA})$$

$$(\text{Depth of focus}) = \pm k_2 / \text{NA}^2$$

Here,  $\lambda$  is the wavelength of the light source used in exposure, NA is the NA (numerical aperture) of the projection lens, and  $k_1$  and  $k_2$  are coefficients relating to processes.

[0003]

In recent years, the use of what are called excimer lasers (KrF, ArF) as well as x-rays, which have shorter wavelengths than the g-rays and i-rays of conventional high pressure mercury lamps, has also been studied. And, on the other hand, there has also been study of higher resolving power and higher depths through phase shift masks or deformation illumination, and practical application is beginning. However, the method of using what are called excimer lasers (KrF, ArF) and x-rays also has high equipment costs, and a phase shift mask or deformation illumination, etc. has problems such as there being cases in which effects cannot be expected depending on circuit patterns.

[0004]

Therefore, attempts to apply the immersion method have been made. For example, described in Examined Patent Application Publication No. 63-49893 is a configuration in which, in the exposure apparatus, a nozzle that has a liquid flow inlet surrounding the front end of a reduction lens is provided, liquid is supplied through this, and liquid is held between the reduction lens and the wafer.

[0005]

Problems to be Solved by the Invention

However, in this prior art, liquid is only supplied, and there are various problems in using it in the actual manufacturing process, such as it not being possible to utilize conventional process technology.

[0006]

The purpose of the present invention is to take the above problems of the prior art into account, provide an immersion type exposure apparatus that is low in cost and with which effectiveness corresponding to the respective wavelengths can be expected at any wavelength regardless of the wavelength of the exposure light source used, such as g-rays, i-rays or an excimer laser, and to provide an immersion type exposure apparatus that utilizes conventional process technology.

[0007]

#### Means to Solve Problems

In order to achieve this purpose, in the present invention, in a projection exposure apparatus equipped with an illumination means that illuminates a reticle, a projection optical means that projects the pattern on the reticle illuminated thereby onto a wafer, and a positioning means that positions the wafer at the prescribed position, the projection optical means is equipped with an optical element that is opposite the exposure surface of the wafer and has a flat surface or a protruding surface that protrudes toward the wafer side and a liquid tank for holding liquid that fills at least the space between the exposure surface of the wafer and the flat surface or the protruding surface of this optical element.

[0008]

The positioning means is normally equipped with an alignment measurement means that detects the wafer position, a focus position detection means that detects the position of the wafer exposure surface with respect to the focus position of the projection optical means, a wafer drive means that holds and drives the wafer in the X and Y directions, which are parallel to the exposure surface thereof, the  $\theta$  direction around an axis that is perpendicular to these, the Z direction, and a direction in which the wafer is tilted in the desired direction, and a wafer conveyance means that carries the wafer onto and out from the holding position of the wafer drive means.

[0009]

There are also cases in which the liquid tank forms a closed space and has a pressurization means, etc. for the liquid inside the liquid tank. There are also cases in which the liquid tank is also positionally secured to the optical means or positionally secured to the XY stage. In the case in which the liquid tank is positionally secured to the optical means, for example, a fine movement stage is arranged inside the liquid tank, the liquid tank is formed by a material with high permeability, and the fine movement stage and the XY stage are magnetically bonded via the liquid tank.

[0010]

#### Actions

As a method of raising the resolving power of the optical system microscope, the so-called immersion method, which fills the space between the objective lens and the sample with a liquid with a high refractive index has been well-known (for example, D.W. Pohl, W. Denk & M. Lanz, Appl. Phys. Lett. 44652 (1984)). Examples of applying this effect to the transfer of the fine circuit patterns of semiconductor elements are "H. Kawata, J.M. Carter, A. Yen, H.I. Smith, Microelectronic Engineering 9 (1989)" and "T.R. Corle, G.S. Kino, USP 5,121,256 (Jun. 9, 1992). Previous theses studied the effects of immersion in exposure, so configuration as an actual semiconductor exposure apparatus is not dealt with, and the latter patent does nothing more than disclose a method of placing an immersion lens near the surface of the wafer.

[0011]

The present invention relates to a specific method for using a production equipment projection exposure apparatus to realize a method of filling the space between the sample and the

objective lens of a microscope with a liquid with a high refractive index, which has been known for a long time, and, through the present invention, an exposure apparatus that utilizes the immersion effect is provided.

[0012]

This "immersion effect" is such that when  $\lambda_0$  is considered the wavelength of the exposure light in the air, and, as shown in Fig. 10,  $n$  is the refractive index of the liquid used for immersion with respect to air,  $\alpha$  is the convergence half angle of the light beam, and  $NA_0 = \sin \alpha$ , when immersion is performed, the aforementioned resolving power and depth of focus are as in the following equations.

$$(\text{Resolving power}) = k_1 (\lambda_0/n)/NA_0$$

$$(\text{Depth of focus}) = \pm k_2 (\lambda_0/n)/(NA_0)^2.$$

That is, the immersion effect is an equivalent value to the wavelength using a  $1/n$  exposure wavelength. In other words, in the case in which a projection exposure optical system with the same NA is used is designed, through immersion it is possible to make the depth of focus  $n$  times. This is effective for all of the various pattern shapes, and it is also possible to combine phase shift methods, deformation illumination methods, etc. that are currently being studied. In order to utilize this effect, accurate control of the purity, homogeneity, temperature, etc. of the liquid is necessary, and in exposure apparatuses that sequentially perform exposure onto the wafer using a step and repeat operation, making the liquid fluctuation and vibration generated during operation as small as possible and the question of how to remove the foam that remains on the wafer surface when the wafer is carried into the liquid are problems. In the present invention, as explained in the embodiments, an apparatus configuration for solving these various problems is proposed, and the immersion effect is thoroughly utilized. Conventionally, in 256 Mbit to 1 Gbit DRAM production, it was thought that it was necessary [to move] from conventional steppers, which have i-rays or excimer lasers as light sources, to x-ray or electron beam (EB) exposure apparatuses, but through the present invention, it is possible to divert conventional manufacturing processes using conventional steppers that use i-rays or excimer lasers as light sources, and production that is also advantageous in terms of cost becomes possible due to technologically established manufacturing processes.

[0013]

This will be explained in more detail below by means of embodiments.

[0014]

#### Embodiments

##### Embodiment 1

Fig. 1 is a block diagram of an immersion type projection exposure apparatus relating to the first embodiment of the present invention. In the drawing, 1 is a reticle, 2 is a wafer that has been coated with a photosensitive material and to which the circuit pattern on the reticle 1 has been exposed and transferred, 3 is an illumination optical system that is equipped with a shutter, a light adjustment apparatus, etc. for projecting the circuit pattern on the reticle 1 onto the wafer 2, 4 is a projection optical system that projects the circuit pattern on the reticle 1 onto the wafer 2, 5 is a reticle stage for holding the reticle 1 and positioning it at the prescribed position, and 6 is an alignment optical system for matching the reticle image with the circuit pattern that has already been transferred onto the wafer 2 to position the reticle 1.

[0015]

If the lens that opposes the surface of the wafer 2 of the projection optical system 4 is called the second optical element 7, this surface that opposes the surface of the wafer 2 of the second optical element 7 is configured so that it is a flat surface or so that it protrudes toward the

surface of the wafer 2 as shown in Fig. 2 and Fig. 3. This is to make it so that an air layer or foam does not remain on the surface of the second optical element 7 when immersion is performed. In addition, for the surface of the optical element 7 to be immersed and the surface of the photosensitive material on the wafer 2, it is preferable to implement coating that has an affinity to the liquid 30 used in immersion. There is a seal 8 between the second optical element 7 and the lens barrel of the projection optical system 4 for preventing penetration of the liquid 30 to the lens barrel. This seal is not necessary if the configuration is such that the second optical element 7 is made thick as shown in Fig. 4 and a function that controls the height of liquid 30 immersion is added.

[0016]

9 is a liquid tank (chamber) for filling with liquid 30, 10 is a wafer cassette, 11-1 through 11-4 are an apparatus for rough positioning of the wafer, 13 is an XY stage for positioning the wafer 2 at the prescribed position, and 14 is fine movement stage that is arranged on the XY stage and has a position compensation function for the  $\theta$  direction of the wafer 2, an adjustment function for the Z position of the wafer 2, and a tilt function for compensating the tilt of the wafer 2. Within the chamber 9 are a wafer conveyance apparatus for carrying the wafer in from the wafer cassette 10 and setting it on the wafer chuck 12, part or the entirety of the rough positioning apparatus 11-1 – 11-4, a wafer chuck 12, an XY stage 13 and a fine movement stage 14.

[0017]

15 is a laser interferometer, 16 is a reference mirror that is attached in the X and Y directions (the Y direction is not shown in the drawing) on the fine movement stage 14 and reflects the light of the laser interferometer 15 to calculate the position of the fine movement stage 14, 17 is a window that is provided on the chamber 9 to allow the light of the laser interferometer 15 to pass through, 18 is a heat insulating material provided on the outside of the chamber 9 that maintains a heat shield with the outside. The chamber 9 itself is configured by a material that has a heat insulation effect, for example, engineering ceramics. In addition, a low heat expansion material, for example, Zerajoule (product name), is used for the material of the chamber 9, and, as shown in Fig. 5, it is also possible to directly attach the laser interferometer 15 to the side surface thereof so that the measurement precision of the laser interferometer 15 is not affected by the air index.

[0018]

The chamber 9 is also provided with a level gauge 19 for measuring the height of liquid 30, a temperature gauge 20 for measuring the temperature of the liquid 30, and a temperature controller 21. The chamber 9 is also provided with a pump 22 for controlling the height of the liquid 30. The pump 22 is also equipped with a function that circulates the temperature controlled liquid 30, and a filter 23 is also set up to filter the impurities in the liquid 30. 24 is a measuring instrument for measuring the refractive index of the liquid 30, 25 is an ultrasonic wave excitation apparatus installed for the purpose of preventing foam from adhering to the surface of the wafer 2 and the surface of the second optical element 7 to make the liquid 30 homogeneous, and 26 is the vibration insulating frame of the exposure apparatus.

[0019]

Next, the actual operation, actions, effects, etc. of the apparatus of the above configuration will be explained. When exposure is performed, first, a wafer 2 that has been coated in advance with a photosensitive material is taken out of the wafer cassette 10 by means of a wafer conveyance apparatus 11-1, and after it has been placed on the wafer position rough detection mechanism 11-2 (normally called a prealignment mechanism) and has undergone rough positioning, the wafer 2 is handled by a wafer feed hand 11-3, and the wafer 2 is set on the wafer



chuck 12 installed in the chamber 9. The wafer 2 that has been placed on the wafer chuck 12 is secured by vacuum suction and undergoes surface correction. Simultaneously with this, the liquid 30 for immersion that is controlled at a constant temperature by a temperature control apparatus 21 is fed into the chamber 9 via a filter 23 by means of a transmission pump 22. When the liquid 30 reaches the prescribed amount, this is detected by the level gauge 19, and the pump 22 is stopped.

[0020]

The temperature of the liquid 30 is continually monitored by a temperature sensor 20, and when it has deviated from the prescribed temperature, the transmission pump 22 is again actuated, and liquid 30 at a constant temperature is circulated. At that time, flow of liquid 30 resulting from circulation of the liquid 30 occurs, and the homogeneity of the liquid 30 is broken down, but measurement of homogeneity is also performed by a refractive index measurement apparatus 24. In addition, foam in the liquid 30, foam that has adhered to the surface of the wafer 2, and foam that has adhered to the surface of the second optical element 7 is removed by the actuation of an ultrasonic wave excitation apparatus 25. This ultrasonic wave excitation has the effect of making the liquid 30 itself homogeneous, and positioning and exposure of the wafer 2 is not affected because the amplitude of the vibration is small, and the frequency is high.

[0021]

When the homogeneity of the liquid 30 is checked by refractive index measurement apparatus 24, in the same way as a normal exposure apparatus, accurate positioning (alignment, focus, etc.) and exposure of the wafer 2 are performed. At this time, through the step and repeat operation, flow of the liquid 30 is generated, but because the interval between the second optical element 7 and the surface of the wafer 2 is approximately several mm to several tens of mm and the liquid 30 has viscosity, the flow of liquid 30 of this portion disappears in a relatively short time. Therefore, a delay period may be taken after the step for each shot or the flow status of the liquid 30 of this portion may be measured with the refractive index measurement apparatus 24 and the sequence continued at the point where the flow has stopped. In addition, since the periphery of the chamber 9 is covered by a heat insulating material 18, it is not normally necessary to actuate the transmission pump 22 and circulate liquid 30 at a constant temperature for approximately the time for processing of one wafer.

[0022]

When exposure of the entire surface of the wafer 2 is completed, the transmission pump 22 is activated again simultaneously with this, and it begins to expel the liquid 30 in the chamber 9. At this time, the level gauge 19 continually senses the height of the liquid 30, and at the point when the height of the liquid 30 has become slightly lower than the surface of the wafer chuck 12, the transmission pump is stopped. Therefore, the amount of expelled liquid 30 is slight. After this, the vacuum of the wafer chuck 12 is cut off, handling of the wafer 2 on the wafer chuck 12 is performed by a carry out hand 14, and it is placed in the wafer cassette 10. At this time, immediately before storage, both surfaces of the wafer 2 may be subjected to a flow of clean air to remove the liquid 30 from the surface of the wafer 2.

[0023]

#### Embodiment 2

Fig. 11 is a block diagram of an immersion type projection exposure apparatus relating to the second embodiment of the present invention, Fig. 12 is a cross sectional drawing of the wafer chuck 12 in Fig. 11, and Fig. 14 is a block diagram that shows a transformation example of the stage portion in Fig. 11. In these drawings, 31 is a conveyance port for carrying the wafer 2 into and out of the chamber 9, 32 is a fluid bearing guide for making movement of the fine movement stage 14 in the horizontal direction possible, 33 is a vacuum pump for reducing the pressure of

the interior of the chamber 9 and removing foam in the liquid 30, 34 is a valve connected to the vacuum pump 33, 35 is a blower that has a nozzle for blowing clean air onto the surface of the wafer 2 to remove liquid 30, 36 is a pressure gauge for measuring the internal pressure of the chamber 9, and 37 is a shutter mechanism built into the wafer chuck. The other configuration is the same as in the case of Fig. 1, but the seal 8 has a function of maintaining the airtightness of the chamber 9. Also, in addition to a function that circulates the liquid 30, the pump 22 is also equipped with a function that controls the pressure of the liquid 30.

[0024]

In this configuration, the point in which operation differs with the case of the first embodiment is that opening and closing of the conveyance port 31 is performed in the respective cases of conveying the wafer 2 into and carrying it out of the chamber 9. In addition, after the wafer 2 is set on the wafer chuck 12, the prescribed amount of liquid 30 has been filled, and the pump 22 has been stopped, a vacuum pump 33 that is connected to the vacuum chamber 9 is actuated, and foam in the liquid 30 is removed. At this time, simultaneously, the ultrasonic wave excitation apparatus 25 is actuated to remove foam in the liquid 30, foam that has adhered to the surface of the wafer 2, and foam that has adhered to the surface of the second optical element 7. When removal of the foam is completed, the vacuum pump 33 is stopped, the valve 34 connected thereto is simultaneously closed, and the pump 22 is actuated to begin pressurization of the liquid 30. Then, at the point when the pressure of the pressure gauge 36 that measures the internal pressure of the chamber 9 has indicated a prescribed value, in the same way as in the case of Embodiment 1, the temperature of the liquid 30 from the temperature sensor 20 is continually monitored. In addition, both sides of the wafer 2 are blown with clean air using a blower 35 immediately before placement in the wafer cassette 10, and the liquid 30 is removed from the surface of the wafer. Other operations are the same as in the case of Embodiment 1.

[0025]

Through this, since the liquid 30 is being pressurized, the flow of the liquid 30 resulting from the step and repeat operation disappears in a shorter period of time. In addition, it is also possible to increase the ability to correct the surface of the wafer 2 on the wafer chuck 12.

[0026]

### Embodiment 3

Fig. 12 is a cross sectional drawing of the wafer chuck portion of an immersion type projection exposure apparatus relating to the third embodiment of the present invention. In the above, the liquid is flowed in and expelled for each wafer, but, here, as shown in Fig. 12, a shutter mechanism 37 is added to the wafer chuck 12, the shutter is opened and vacuum suction is performed only in the case in which the wafer 2 is on the wafer chuck 12, and processing can be performed even while the liquid 30 has been filled 30. Through this increases in throughput can be pursued. In such a case, the conveyed wafer 2 is inserted by means of a wafer feed hand 11-3 into the liquid 30 at an angle or vertically with respect to the liquid 30 so that foam does not remain, and it is set on the wafer chuck 12 after being made horizontal inside the liquid 30.

[0027]

### Embodiment 4

Fig. 6 is a cross sectional drawing that shows the stage portion of an immersion type projection exposure apparatus relating to the fourth embodiment of the present invention. This is such that, in the configuration of Embodiment 1, the drive system of the XY stage 13 is placed outside the chamber 9 to prevent impurities from being mixed into the liquid 30. In this case, as shown in the same drawing, the entirety of the XY stage 13 is arranged outside the chamber 9, the chamber 9 is placed on top of the XY stage 13, and positioning is performed together with the chamber 9. In this case, since a step and repeat operation is performed on the entire liquid 30, the

liquid 30 inside the chamber 9 flows according to the degree of acceleration during movement, so the structure is such that a stabilizer 29 that combines a plate in a mesh shape as shown in Fig. 7 is inserted into the liquid 30 at the time of the step, and the flow and waves of the liquid 30 are controlled. Note that it is possible to apply the same type of stage configuration to the configuration of Embodiment 2 as well. In addition, as shown in Fig. 13, the stabilizer 29 may be made into a shape in which a hole is provided at the center for passing through the projection lens 4.

[0028]

#### Embodiment 5

Fig. 8 is a cross sectional drawing that shows the stage portion of an immersion type projection exposure apparatus relating to the fifth embodiment of the present invention. As shown in the configuration in Embodiment 1, this is configured in such a way that the drive system of the XY stage 13 is placed outside the chamber 9 in the same way as the case of Embodiment 4 to prevent impurities from mixing in with the liquid 30. However, in this case, as shown in the same figure, the configuration is such that the fine movement stage 14 within the chamber 9 is indirectly driven by arranging a magnet 27 on the bottom surface of the fine movement stage 14, forming the bottom surface of the chamber 9 using a material with permeability to magnetically bond it with the magnet 28 on the XY stage 13 on the bottom portion of the chamber 9, and moving the XY stage 13 with the bottom surface of the chamber 9 as the guide of the fine movement stage 14.

[0029]

#### Embodiment 6

Fig. 14 is a cross sectional drawing that shows the stage portion of an immersion type projection exposure apparatus relating to the sixth embodiment of the present invention. As shown in the configuration in Embodiment 2, it is configured so that the fine movement stage 14 within the chamber 9 is indirectly driven by placing the drive system of the XY stage 13 outside the chamber 9 in the same way as the case of Embodiment 5 to prevent impurities from mixing in with the liquid 30, arranging a magnet 27 on the bottom surface of the fine movement stage 14, forming the bottom surface of the chamber 9 using a material with permeability to magnetically bond it with the magnet 28 on the XY stage 13 on the bottom portion of the chamber 9, and moving the XY stage 13 with the bottom surface of the chamber 9 as the guide of the fine movement stage 14. Also, in addition, a nozzle that blows out liquid is provided on the lower surface of the fine movement stage 14, and a fluid bearing guide 32 is formed so that the liquid 30 used in immersion is blown out from there. Through this, it is possible to lighten the mass of the movable portion during the step and repeat operation, so it is possible to further increase throughput.

[0030]

#### Embodiment 7

Fig. 9 is a cross sectional drawing that shows the stage portion of an immersion type projection exposure apparatus relating to the seventh embodiment of the present invention. This is such that only the portion that includes the wafer chuck 12 is arranged in the chamber 9 or the wafer chuck 12 is directly formed on the bottom surface of the chamber 9, and the chamber 9 is arranged on the fine movement stage 14. In this case, these are formed by a low heat expansion material so that the bottom surface of the chamber 9 and the two surfaces that are adjacent thereto are respectively at right angles, and it is also possible to make these two surfaces the reference surfaces for the laser interferometer 15 measurements.

[0031]

Note that, in the above respective embodiments, it is also possible to configure the conveyance apparatus for carrying the wafer onto the wafer chuck 12 or carrying the wafer out from on top of the chuck 12 both inside the chamber 9 and outside the chamber 9.

[0032]

#### Effects of the Invention

As explained above, through the present invention, it is possible to apply an immersion method that increases resolution and depth of focus to an exposure apparatus in a condition in which it can be thoroughly utilized in actual manufacturing processes. Therefore, it is possible to provide an immersion type exposure apparatus that is low in cost and with which effects that correspond to the respective wavelengths can be expected at any wavelength no matter what the wavelength of the exposure light source, be it a g-ray, and i-ray or an excimer laser, and to further provide an immersion type exposure apparatus that is able to utilize conventional process technologies.

#### Brief Description of the Drawings

##### Fig. 1

Fig. 1 is a block diagram that shows the configuration of an immersion type projection exposure apparatus relating to the first embodiment of the present invention.

##### Fig. 2

Fig. 2 is a cross sectional view of the optical element applied to the apparatus of Fig. 1.

##### Fig. 3

Fig. 3 is a cross sectional view of another optical element applied to the apparatus of Fig. 1.

##### Fig. 4

Fig. 4 is a cross sectional view of yet another optical element \*\* applied to the apparatus of Fig. 1.

##### Fig. 5

Fig. 5 is a cross sectional view that shows the case in which a laser interferometer is directly attached to the side surface of the chamber in the apparatus of Fig. 1.

##### Fig. 6

Fig. 6 is a cross sectional view that shows the stage portion of an immersion type exposure apparatus relating to the fourth embodiment of the present invention.

##### Fig. 7

Fig. 7 is an oblique view of a stabilizer applied to the apparatus of Fig. 6.

##### Fig. 8

Fig. 8 is a cross sectional view that shows the stage portion of an immersion type exposure apparatus relating to the fifth embodiment of the present invention.

##### Fig. 9

Fig. 9 is a cross sectional view that shows the stage portion of an immersion type exposure apparatus relating to the seventh embodiment of the present invention.

##### Fig. 10

Fig. 10 is a cross sectional view for explaining the immersion effect.

##### Fig. 11

Fig. 11 is a block diagram of an immersion type projection exposure apparatus relating to the second embodiment of the present invention.

##### Fig. 12

Fig. 12 is a cross sectional view of the wafer chuck in Fig. 11.

##### Fig. 13

Fig. 13 is an oblique view of a stabilizer applied to the apparatus of Fig. 14.

Fig. 14

Fig. 14 is a schematic view that shows a transformation example of the stage portion in Fig. 11.

Explanation of Codes

1: reticle, 2: wafer, 3: illumination optical system, 4: projection optical system, 5: reticle stage, 6: alignment optical system, 7: optical element, 8: seal, 9: liquid tank, 10: wafer cassette, 12: wafer chuck, 11-1 through 11-4: rough positioning apparatus, 13: XY stage, 14: fine movement stage, 15: laser interferometer, 16: reference mirror, 17: window, 18: heat insulation material, 19: level gauge, 20: temperature gauge, 21: temperature controller, 22: pump, 23: filter, 24: measuring equipment, 25: ultrasonic wave excitation apparatus, 26: vibration insulating frame, 27, 28: magnet, 29: stabilizer, 30: liquid, 31: conveyance port, 32: fluid bearing guide, 33: vacuum pump, 34: valve, 35: blower, 36 pressure gauge, and 37: shutter mechanism.

Fig. 2

Fig. 3

Fig. 4

Fig. 5

Fig. 7

Fig. 12

Fig. 1

Fig. 6

Fig. 8

Fig. 11

Fig. 9

Fig. 10

Fig. 13

Fig. 14

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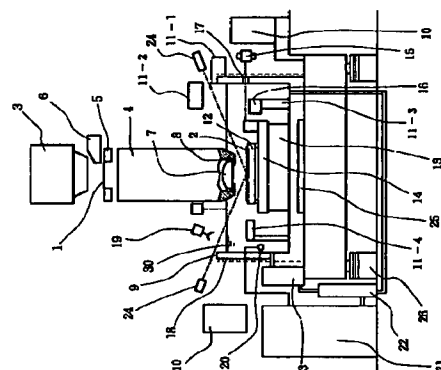
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(54)【発明の名称】  
液浸式投影露光装置

【57】【要約】

【目的】従来のプロセス技術を生かせる複浸式露光装置を提供する。

【構成】 レシカルを照写する照明手段、これによってレシカルを投影されたレシカル上のパターンをウェハ上に投影する投影光学手段、ウェハを所定位置に位置決めする位置決め手段を得る。投影光学手段において、投影光学手段はウェハ上の露光面に対向し、平面もしくはウェハ面へ凸凹パターンを有する光学素子、およびこの光学素子から平面もしくはウェハの露光面との距離を少なくとも幾度も変化する状態を保持するための駆動部を具備する。



【請求項28】 被覆内に供給された液体の温度を制御し制御する温度制御手段を備える請求項14または15記載の液浸式投影露光装置。

【請求項29】 被覆内に供給された液体の屈折率を規定する屈折率調整手段を備える請求項14または15記載の液浸式投影露光装置。

【請求項30】 被覆内に供給された液体の流動を阻止するスクビラビザを備える請求項14または15記載の液浸式投影露光装置。

【請求項31】 被覆の外壁は、断熱材料で覆われている請求項14または15記載の液浸式投影露光装置。

【請求項32】 ウェハ駆動手段は、ウェハを吸着して保持するウェハチャックを備え、このウェハチャックはウェハを真空吸引して保持するための通路、およびこの通路内に液体が流入するのを防止するシャッターを有することを特徴とする請求項14または15記載の液浸式投影露光装置。

【請求項33】 ウェハ駆動手段はウェハを被覆内の露光位置に搬入しおよび搬出するウェハ搬送手段を備え、このウェハの搬送手段は、少なくとも一部が被覆内に配置され、この搬送手段を有する請求項14または15記載の液浸式投影露光装置。

【請求項34】 搬送手段は、被覆内に保持された液体にウェハを垂直もしくは斜めに搬入し、液体中でウェハを水平にする手段を有する請求項33記載の液浸式投影露光装置。

【請求項35】 搬送手段が被覆内に保持された液体中からウェハを搬出する際に、ウェハの少なくとも一部をエアブローする手段を有する請求項33記載の液浸式投影露光装置。

【請求項36】 液体を被覆内に供給しおよび排出させるポンプを有することを特徴とする請求項14または15記載の液浸式投影露光装置、がある。

【請求項37】 ウェハ駆動手段はXおよびY方向に移動するXYステージおよびこれによってXおよびY方向に移動されかつウェハを任意の方向に傾ける駆動ステージを有し、被覆は駆動ステージ上に固定されていることを特徴とする請求項7または8記載の液浸式投影露光装置。

【請求項38】 被覆の底面がウェハを保持するウェハチャックを構成していることを特徴とする請求項37記載の液浸式投影露光装置。

【請求項39】 被覆の少なくとも側面が直交した平面で構成され、これらの平面がレーザ光の反射面を構成していることを特徴とする請求項37記載の液浸式投影露光装置。

【請求項40】 被覆の底面部分と駆動ステージ面とが液体ベアリングの平面ガイドを構成していることを特徴とする請求項18記載の液浸式投影露光装置。

【発明の詳細な説明】

はウェハの露光面に対向し、平面もしくはウェハ側へ凸んだ凸面を有する光学素子、およびこの光学素子の平面もしくは凸面とウェハの露光面との間を少なくとも満たす液体を保持するための液槽を具備する。

【0008】位置決め手段は、通常、ウェハ位置を検出するアライメント制御手段と、投影光学手段のフオーカス位置に対するウェハ露光面の位置を検出するフオーカス位置検出手段と、ウェハをその露光面に安全なXおよびY方向、これらに無関係の回りのθ方向、Z方向、ならびにウェハを任意の方向に傾ける方向にウェハを保持して駆動するウェハ駆動手段と、ウェハ駆動手段の保持位置上にウェハを搬入しおよび搬出するウェハ搬送手段とを備える。

【0009】被覆は閉空間を構成し、被覆内の液体の加圧手段等を有する場合もある。被覆はまた、光学手段に対して位置的に固定され、あるいはXYステージに位置的に固定されている場合もある。被覆が光学手段に対して位置的に固定されている場合は、例えば、駆動ステージが被覆内に配置され、被覆は透明性の高い材料で構成され、そして被覆を介して駆動ステージとXYステージが気密結合される。

【0010】

【作用】光学式顕微鏡の解像力をあげる方法としては、従来から、対物レンズと被検体の間を高屈折率の液体で満たす、所謂、液浸法が知られている（例えば、D. W. Pohl, W. Denk & M. Lanz, App

l. Phys. Lett. 44652 (1984)）。この効果を半導体素子の微細回路パターンへの転写に適用した例としては、『H. Kawata, J. M. Carter, A. Yen, H. I. Smith, Micro electronic Engineering 9 (1989)』、或は、『T. R. Corle, G. S. kino, USP 5, 121, 255 (Jun. 9, 1992)』がある。前論文は、露光における液浸の効果を検討したもので、実用的な半導体露光装置としての構成を論じておらず、後者のパタントは、液浸レンズをウェハの表面近くに置く方法を開示しているに過ぎない。

【0011】本発明は、従来から知られている顕微鏡の対物レンズと被検体の間を高屈折率の液体で満たすという方法を、生産設備としての液浸露光装置で実現するもの、具体的方法に關するものであり、本発明によれば、液浸の効果を利用した露光装置を提供することが可能となる。

【0012】この「液浸の効果」とは、λを露光の空気中での波長とし、また、図10に示すように、nを液浸に使用する液体の空気に対する屈折率、αを光線の収束半角とし、NA<sub>0</sub>=sinαとすると、液浸した場合は、前述の解像力および無解像度は、次のようになる。 (解像力)=k<sub>1</sub> (λ<sub>0</sub>/n) / NA<sub>0</sub>

(無解像度)=±k<sub>2</sub> (λ<sub>0</sub>/n) / (NA<sub>0</sub>)<sup>1</sup> すなわち、液浸の効果は波長が1/nの露光波長を使用するのと等価である。言い換えば、同じNAの投影光学系を設計した場合、液浸により、焦点深度をn倍にすることができ、これは、あらゆるパターンの形状に対する有効であり、更に、現在検討されている位相シフト動作でウェハ上に逐次露光して行く露光装置では、この効果を生かすためには、液体の粘度、均一性、温度等の密着管理が必要であり、ステパ・アンド・リピート動作でウェハ上に逐次露光して行く露光装置では、動作中に発生する液体の流動や運動や微小な力などによって、ウェハを液体内に搬入する際のウェハ表面に残留する気泡をいかにして除去するか等が問題になる。本発明では、実施例で説明するように、これらの諸問題を解決するための装置の構成を提案し、液浸の効果を十分活かせるようにしている。従来、256Mbit〜1GbitのDRAMの生産では、i線、エキシマレーザを光源とする従来のステップから、X線、或は電子ビーム(E<sup>B</sup>)の露光装置が必要と考えられていたが、本発明によつて、i線、或はエキシマレーザを光源とする従来のステッパで従来の製造プロセスを捉用出来、技術的に独立された製造プロセスでコスト的にも有利な生産が可能となる。

【0013】以下に、実施例を通じてより詳細に説明する。

【0014】

【実施例】

図1は、本発明の第1の実施例に係る液浸式投影露光装置の構成図である。図中、1はレチクル、2は感光剤が塗布され、レチクル1上の回路パターンが露光・転写されるウェハ、3はウェハ2上にレチクル1上の回路パターンを投影するためのシャッター及び露光装置等を備えた照明光学系、4はウェハ2上にレチクル1上の回路パターンを投影する投影光学系、5はレチクル1を保持し、所定の位置に位置決めするためのレチクルステージ、6はレチクル1を位置決めするため、及びレチクル像をウェハ2上に既に転写されている回路パターンに合致させるためのアライメント光学系である。

【0015】投影光学系4のウェハ2表面に対向するレンズは、第2の光学素子7と称することとすると、この第2の光学素子7のウェハ2表面に対向する面は、図2および図3に示すように、平面あるいはウェハ2表面に向かつて凸となるように構成されている。これは、液浸する際に、第2の光学素子7表面に空気層や気泡が残らない様に、第2の面である。また、液浸される光学素子7の表面およびウェハ2上の露光剤の表面は、液浸に使用する液体30と良好性のあるコーティングを施すことが望ましい。第2の光学素子7と投影光学系4の端面との間には、液体30の端面への搬入を防ぐためのシール8が

る。このシールドは、第2の光学素子7の厚さを、図1に示すように厚く取り、液体30を厚く高さを管理する機能を付加するように構成しければ不都合である。

【0016】9は液体30を満たしたための機構（チャンバ9）、10はウエハセット、12はウエハ2を保持するためのウエハチャック11・11-1〜11-4はウエハ2の相対位置決め装置、13はウエハ2を所定の位置に位置決めするためのXYステージ、14はXYステージ上に配置され、ウエハ2の2方向位置の修正機能、ウエハ2のZ位置の調整機能、およびウエハ2の傾きを修正するためのチルト機能と有する微動ステージである。チャンバ9の中に、ウエハセット10からウエハ2を搬入し、ウエハチャック12上にセットするためのウエハ搬送装置、相対位置決め装置11・11-1〜11-4の一部もしくは全体、ウエハチャック12、XYステージ13、および微動ステージ14がある。

【0017】15はレーザ干渉計、16は微動ステージ14上にXおよびY方向（Y方向は不図示）に取り付けられ、微動ステージ14の位置を計測するためにレーザ干渉計15の光を反射する参照ミラー、17はレーザ干渉計15の光を通達させるためのチャンバ9に取付けられた、18はチャンバ9の外側に取付けられ、外部との気密遮断を保つ断熱材である。チャンバ9自体を断熱効果のある材料、例えばエッジインリアリンスセラミックで構成すれば、断熱材18は不要である。更に、チャンバ9の材質を低熱導率材、例えばばね鋼（商品名）を使用し、図1に示すように、レーザ干渉計15をその側面に直接取り付け、レーザ干渉計15の計測精度が空気のインデックスの影響を受けないようにすることも可能である。

【0018】チャンバ9にはまた、液体30の高さを測定するための断面ゲージ19、液体30の厚度を測定する厚度計20、および厚度コントローラ21が設けられている。チャンバ9には、さらに、液体30の高さを制御するためのポンプ22が設けられている。ポンプ22は厚度制御された液体30を循環させる機能も備え、液体30中の不純物をろ過するためのフィルタ23も具備されている。24は液体30の厚さを測定するための測定器、25は液体30を均質にするため、およびウエハ2表面や第2の光学素子7表面に気泡が付着するのを防ぐ目的で設置された超音波加湿装置、26は露点装置の防湿装置である。

【0019】次に、上記構成の装置の実験的動作、作用、および効果等を説明する。露光をさせる際には、まず、あらかじめ露光材料を搬送してあるウエハ2を搬送装置11・11-1で、ウエハセット10より取り出し、ウエハ2を保持した状態で、相対位置決めした後、ウエハ2を送り込みハンド11-3やウエハ2をハンドリングし、チャンバ9内に設置されたウエハチャック1

2上にウエハ2をセットする。ウエハチャック12上に搬送されたウエハ2は、パキューム吸着によって固定され、平面矯正される。これと同時に、厚度制御装置21で一定厚度に制御された液体30が搬送ポンプ22によって、フィルタ23を介して、チャンバ9内に入り込み、液体30が所定の量になると、断面ゲージ19がこれを検知して、ポンプ22を停止する。

【0020】液体30の厚度は、厚度センサー20により常時監視しており、所定の厚度からずれた場合は、再度搬送ポンプ22を作動させ、一定厚度の液体30を循環させるようになっている。その際、液体30の循環による、液体30の流動が起こり、液体30の均一性が損われるが、厚度制御装置24で、均一性の測定も行われ、また、液体30中の気泡、ウエハ2表面に付着した気泡、第2の光学素子7表面に付着した気泡は、超音波加湿装置25を作動させて除去する。この超音波加湿装置25は、液体30自体を均一にする効果も有しており、流動の振幅が小さく、周波数が高いために、ウエハ2の位置決めや露光には影響が少ない。

【0021】厚度制御装置24で液体30の均一性が確認されると、通常の露光装置と同様に、ウエハ2の精密位置決め（アライメント、フォーカス等）と露光が行われる。このとき、ステージ・アンド・リピート動作により、液体30の流動が安定するが、第2の光学素子7とウエハ2表面との間隔が数mmから数十mm程度であり、液体30が粘性を有する事から、比較的時間で、この部分の液体30の流動はなくなる。従って、各ショット毎にステージ後に通過時間を取るか、厚度制御装置24で、この部分の液体30の流動状態を測定し、流動が停止した時点でレーザ干渉計を継続させれば良い。また、チャンバ9の外周は、断熱材18で覆ってあるため、通常、1枚のウエハ2を処理する時間短縮は、搬送ポンプ22を作動させ、一定厚度の液体30を循環させる必要はない。

【0022】ウエハ2の全面の露光が完了すると、これと同時に搬送ポンプ22が再び作動し、チャンバ9内の液体30を抽出し始める。この時、断面ゲージ19が常時液体30の高さを検知しており、液体30の高さがウエハチャック12面より低く低くなった時点で、搬送ポンプを停止させる。従って、排出する液体30の量は、恒かである。その後、ウエハチャック12のパキュームを切り、搬出ハンド11-4で、ウエハチャック12上のウエハ2をハンドリングして、ウエハセット10に収納する。この時、収納直前に、ウエハ2の両面をクリーンなエアでブローして、液体30をウエハ2表面から除去するようにしてもよい。

【0023】変形例2

図11は本発明の第2の実施例に係る複式露光装置の構成図、図12は図11におけるウエハチャック12の断面図、そして図14は図11におけるステージ第

分の形状例を示す模式図である。これらの図において、31はウエハ2をチャンバ9内に搬入および搬出するための搬送口、32は微動ステージ14を水平方向に移動可能にするための流体ベアリングガイド、33はチャンバ9の内面を包囲して、液体30中の気泡を除去するための真空ポンプ、34は搬送ポンプ33に接続されたバルブ、35は液体30を排出するためにクリーンなエアをウエハ2表面に吹き付けるためのノズルを有するブロー、36はチャンバ9の厚さを測定するための圧力計、37はウエハチャック12に内蔵されたジャグ機構である。他の構成は図1の構成と同様であるが、シールドはチャンバ9の密閉を保たせる機能も有する。また、ポンプ22は、液体30を循環させる機能に加え、液体30の圧力をコントロールする機能も備える。

【0024】この構成においては、実施例1の場合と動作が異なる点として、チャンバ9内ウエハ2を搬送しおよび搬出するそれぞれの場合において、搬送口31の開閉が行われる。またウエハ2をウエハチャック12上にセットし、液体30を所定量満たしてポンプ22を停止した後、さらに、パキュームチャンバ9に接続して真空ポンプ33が作動され、液体30中の気泡が除去される。このとき同時に、超音波加湿装置25を作動させて、液体30中の気泡、ウエハ2表面に付着した気泡、第2の光学素子7表面に付着した気泡を除去する。気泡を除去し、真空ポンプ33は停止し、同時に、これに接続されているバルブ34が開かれ、ポンプ22が作動して、液体30を加圧し始める。そしてチャンバ9の内圧を測定している圧力計36の圧力が所定の値を示した時点で、実施例1の場合と同様に、厚度センサー20による液体30の厚度の常時監視を行う。また、ウエハセット10への取納直前には、ブロー35によりウエハ2の両面がクリーンなエアでブローされ、液体30がウエハ2表面から除去される。他の動作は実施例1の場合と同様である。

【0025】これにより、液体30が加圧されているため、ステージ・アンド・リピート動作による液体30の流動は、より短時間で済む。また、加圧された液体30の圧力によって、ウエハチャック12上のウエハ2の平面矯正能力も増加させることが可能である。

【0026】変形例3

図12は本発明の第3の実施例に係る複式露光装置のウエハチャック部分の断面図である。上述においては、ウエハ毎に液体を搬入し排出するようにしているが、ここでは、図12に示すように、ウエハチャック12にジャグ機構37を付加し、ウエハ2がウエハチャック12上にある場合のみジャグ機構を働いてパキューム吸着によるようにして、液体30を満たしたままでも処理できるようにしている。これにより、スループットの向上が図られる。この場合、搬送されるウエハ2は、ウエハ送り込みハンド11-3によって、液体30に対して斜め搬

は垂直に気泡が湧かないように液体30中に搬入され、液体30中で水平にされてウエハチャック12上にセットされる。

【0027】変形例4

図13は、本発明の第4の実施例に係る複式露光装置のステージ部分を示す断面図である。これは、実施例1の構成において、液体30中に不純物が混入するのを防ぐために、XYステージ13の運動系を、チャンバ9の外側に置くように構成したものである。この場合、図1に示すように、XYステージ13全体がチャンバ9の外に配置され、XYステージ13上にチャンバ9を載せてチャンバ9ごと位置決めされる。この場合、液体30全体をステージ・アンド・リピート動作させるために、チャンバ9内部の液体30が移動時の加速度によって流動するので、図13に示すような、板材をメッシュ状に組み合わせたスタビライザ29をステージ時に液体30中に挿入して、液体30の流動や液立ちを抑えられ、構造になっている。なお、実施例2の構成に對しても、同様のステージ構成を適用することができ、また、スタビライザ29を、図13に示すように、中に投影レンズ4を通すための穴を設けられた形状にしてもよい。

【0028】変形例5

図14は、本発明の第5の実施例に係る複式露光装置のステージ部分を示す断面図である。これは、実施例1の構成において、液体30中に不純物が混入するのを防ぐために、XYステージ13の運動系を、実施例4の場合と同様に、チャンバ9の外側に置くように構成したものである。ただしこの場合は、図1に示すように、微動ステージ14の底面に磁石27を配し、チャンバ9の底面を透磁性の材料で構成して、磁石28と磁気的に結合させ、XYステージ13上の磁石28と磁気的に結合させ、チャンバ9の底面を微動ステージ14のガイドとして、XYステージ13を移動させることにより、チャンバ9内の微動ステージ14を間接的に駆動させるように構成する。

【0029】変形例6

図15は、本発明の第6の実施例に係る複式露光装置のステージ部分を示す断面図である。これは、実施例2の構成において、液体30中に不純物が混入するのを防ぐために、XYステージ13の運動系を、実施例5の場合と同様に、チャンバ9の外側に置き、微動ステージ14の底面に磁石27を配し、チャンバ9の底面を透磁性の材料で構成して、チャンバ9の下側にあるXYステージ13上の磁石28と磁気的に結合させ、チャンバ9の底面を微動ステージ14のガイドとして、XYステージ13を移動させることにより、チャンバ9内の微動ステージ14を間接的に駆動させるように構成したのである。またさらに、微動ステージ14下面に液体を吹き出すノズルを設け、液膜に使用している液体30をそこから排出させるようにして、液体ベアリングガイド32を



構成している。これにより、ステップ・アンド・リピート動作時の可動部分の重量を軽減することができ、スループットをさらに向上させることができる。

【0030】実施例7

図4は、本発明の第7の実施例に係る複式露光装置のステージ部分を示す断面図である。これは、ウエハチャック12を含む部分のみをチャンバ9内に配置し、チャンバ9の底面にウエハチャック12を直接構成し、駆動ステージ14上にチャンバ9を配置したものである。この場合、チャンバ9の底面とこれに隣接する2面とがそれぞれ直角になるようにこれを低反射材料で構成し、この2面をレーザ平砂計15の計測用の参照面とすることも可能である。

【0031】なお、上述の実施例において、ウエハをウエハチャック12上に搬入しあるいはチャック12上からウエハを搬出するための搬送装置は、チャンバ9の中に構成することもチャンバ9の外に構成することも可能である。

【0032】

【発明の効果】以上説明したように本発明によれば、解像度や焦点深度を高める露光法を、装置の製造工程で十分に使用できる露光装置に適用することができ、レーザ等の、露光光源の波長に拘らず、どの波長でも、それぞれの波長に応じた効果を期待できるコストが安い複式露光装置を提供し、更には、従来のプロセス技術を生かせる複式露光装置を提供することができる。

【図1】 本発明の第1の実施例に係る複式露光装置の構成を示す構成図である。

【図2】 図1の装置に適用される光学素子の断面図である。

【図3】 図1の装置に適用される他の光学素子の断面図である。

【図4】 図1の装置に適用されるさらに他の光学素子

の断面図である。

【図5】 図1の装置において、チャンバの側面にレーザ平砂計を直接取り付け付けた場合を示す断面図である。

【図6】 本発明の第4の実施例に係る複式露光装置のステージ部分を示す断面図である。

【図7】 図5の装置に適用されるスタビライザの斜視図である。

【図8】 本発明の第5の実施例に係る複式露光装置のステージ部分を示す断面図である。

【図9】 本発明の第7の実施例に係る複式露光装置のステージ部分を示す断面図である。

【図10】 複露の効果を示すための断面図である。

【図11】 本発明の第2の実施例に係る複式露光装置の構成図である。

【図12】 図11におけるウエハチャックの断面図である。

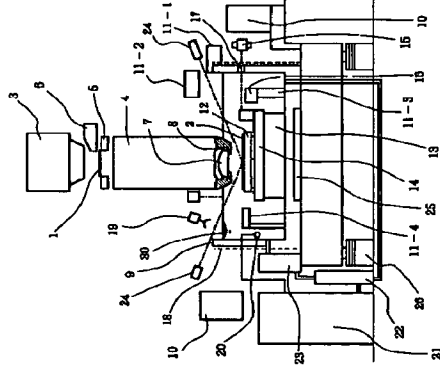
【図13】 図14の装置に適用できるスタビライザの斜視図である。

【図14】 図11におけるステージ部分の変形例を示す構成図である。

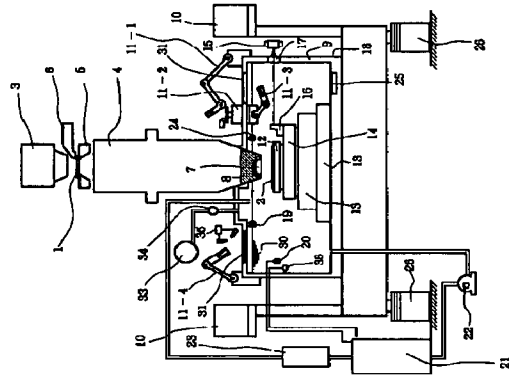
【符号の説明】

- 1：レチクル、2：ウエハ、3：照明光学系、4：投影光学系、5：レチクルステージ、6：アライメント光学系、7：光学素子、8：シールド、9：露光、10：ウエハセット、11：ウエハチャック、11-1～11-4：相位置決め装置、13：XYステージ、14：駆動ステージ、15：レーザ平砂計、16：参照ミラー、17：磁、18：断熱材、19：検出ゲージ、20：傾度計、21：温度コントローラ、22：ポンプ、23：フイルム、24：測定器、25：超音波加振装置、26：防塵室、27、28：磁石、29：スタビライザ、30：球体、31：排出口、32：流体ベアリングガイド、33：真空ポンプ、34：バルブ、35：プロフ、36：圧力計、37：シャック機構。

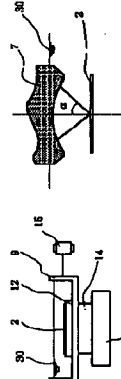
【図1】



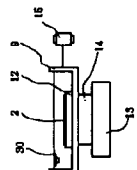
【図11】



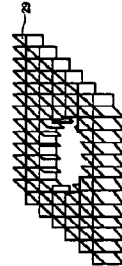
【図10】



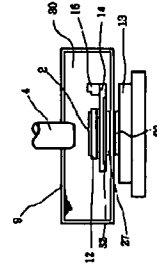
【図9】



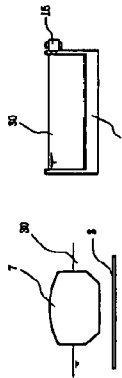
【図13】



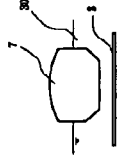
【図14】



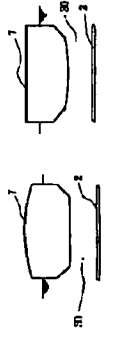
【図5】



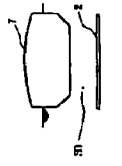
【図4】



【図2】



【図3】



【図7】



【図12】

